CDS130 Mid-term exam Answer Key

- Write your name at the top of your answer page.
- This is a closed book exam.
- You may not use a calculator.
- You may not use MATLAB during exam except the last two problems.
- Absolutely no interaction between students is allowed.
- Partial credit may be awarded ONLY if work is shown.
- Duration for this exam: 75 minutes.

Q1. (5 points)

$(-7)_{10}=(\quad)_2$ (using the excess-127 method) .

Answer:

binary	unsinged	excess-127
0111 1111	127	0

Therefore, $(-7)_{10}$ in the excess-127 method corresonds to the unsigned number 120, which which can be represented by

$(0111\ 1000)_2$

Q2. (5 points) Convert decimal -127 to 8-bit binary using the two's complement method .

Answer:

The positive counderpart of -127 is 127. Represened in binary, it is:

0111 1111

to convert this number to its two's complement, we use two steps.

Step 1. Flip over the bits: 1000 0000
Step 2. add 1: 1000 0001

Q3. (5 points) How many bits are needed to generate 1048 bit-patterns?

Answer:
The totol bit patterns represented by N bits is 2^N.

With 10 bits, we can generate 2^{10} = 1024 bit patterns.
With 11 bits, we can generate 2^{11} = 2048 bit patterns.

Therefore, 11 bits are needed to generate 1048 bit patterns.

Q4. (5 points) Carry out binary division and find the results of
0 1 1 1 0 0 0 1 1 divided by 0 1 1 0 1

The correct answer is:

10001 R 11 0

Q5. (5 points) There are three different computer types on the Voyager spacecraft and there are two of each kind. Total number of words among the six computers is about 32, 000.

Computer Command System (CCS) - 18-bit word, interrupt type processors (2) with 4096 words each of the memory plates.

Flight Data System (FDS) - 16-bit word machine (2) with 8198 words each

Attitude and Articulation Control System (AACS) - 18-bit word machines (2) with 4096 words each.

How much memory (in terms of bytes) is equipped on the Voyager spacecraft?

On the CCS, the total number of bits is: $2 \times 4096 \times 18 = 147,456\, bits$
On the FDS, the total number of bits is: $2 \times 8198\, x\, 16 = 262,336\, bits$
On the AACS, the total number of bits is: $2 \times 18 \times 4096 = 147,456\, bits$

The total amount of bits is:
$147,456 + 262,336 + 147,456 = 557,248\, bits$

In terms of bytes, this corresponds to :

69. 656 bytes or 69 kB

Q6. (5 points) A forensic computer scientist is able to examine a file at the low-level of bytes for analyzing malware. A snippet of the document with the binary format reads:

0101 0011 0110 1000 0101 0101 0111 0100
0100 0100 0110 1111 0101 0111 0110 1110

What is the content of the document displayed above according to the ASCII encoding table?

According to the ASCII encoding table, we need 8 bits for each character. The first binary group 0101 00 11 is equivalent to $(53)_{hex}$ or $(83)_{10}$, which corresponds to the letter “S”.

The encoded letters are:

S h U t D o W n

Dec	Hex	Name	Char	Ctrl-char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char
0	0	Null	NUL	CTRL-@	32	20	Space	64	40	@	96	60	`
1	1	Start of heading	SOH	CTRL-A	33	21	!	65	41	A	97	61	a
2	2	Start of text	STX	CTRL-B	34	22	"	66	42	B	98	62	b
3	3	End of text	ETX	CTRL-C	35	23	#	67	43	C	99	63	c
4	4	End of xmit	EOT	CTRL-D	36	24	$	68	44	D	100	64	d
5	5	Enquiry	ENQ	CTRL-E	37	25	%	69	45	E	101	65	e
6	6	Acknowledge	ACK	CTRL-F	38	26	&	70	46	F	102	66	f
7	7	Bell	BEL	CTRL-G	39	27	'	71	47	G	103	67	g
8	8	Backspace	BS	CTRL-H	40	28	(	72	48	H	104	68	h
9	9	Horizontal tab	HT	CTRL-I	41	29	)	73	49	I	105	69	i
10	0A	Line feed	LF	CTRL-J	42	2A	*	74	4A	J	106	6A	j
11	0B	Vertical tab	VT	CTRL-K	43	2B	+	75	4B	K	107	6B	k
12	0C	Form feed	FF	CTRL-L	44	2C	,	76	4C	L	108	6C	l
13	0D	Carriage feed	CR	CTRL-M	45	2D	-	77	4D	M	109	6D	m
14	0E	Shift out	SO	CTRL-N	46	2E	.	78	4E	N	110	6E	n
15	0F	Shift in	SI	CTRL-O	47	2F	/	79	4F	O	111	6F	o
16	10	Data line escape	DLE	CTRL-P	48	30	0	80	50	P	112	70	p
17	11	Device control 1	DC1	CTRL-Q	49	31	1	81	51	Q	113	71	q
18	12	Device control 2	DC2	CTRL-R	50	32	2	82	52	R	114	72	r
19	13	Device control 3	DC3	CTRL-S	51	33	3	83	53	S	115	73	s
20	14	Device control 4	DC4	CTRL-T	52	34	4	84	54	T	116	74	t
21	15	Neg acknowledge	NAK	CTRL-U	53	35	5	85	55	U	117	75	u
22	16	Synchronous idle	SYN	CTRL-V	54	36	6	86	56	V	118	76	v
23	17	End of xmit block	ETB	CTRL-W	55	37	7	87	57	W	119	77	w
24	18	Cancel	CAN	CTRL-X	56	38	8	88	58	X	120	78	x
25	19	End of medium	EM	CTRL-Y	57	39	9	89	59	Y	121	79	y
26	1A	Substitute	SUB	CTRL-Z	58	3A	:	90	5A	Z	122	7A	z
27	1B	Escape	ESC	CTRL-[	59	3B	;	91	5B	[	123	7B	{
28	1C	File separator	FS	CTRL-\	60	3C	<	92	5C	\	124	7C	|
29	1D	Group separator	GS	CTRL-]	61	3D	=	93	5D	]	125	7D	}
30	1E	Record separator	RS	CTRL-^	62	3E	>	94	5E	^	126	7E	~
31	1F	Unit separator	US	CTRL-_	63	3F	?	95	5F	_	127	7F	DEL

Q7. (5 points) Suppose signed integers are represented by 11 bits in a computer architecture. Show respectively the range of the integers (in base 10) in the following methods:

(1) Sign-and-magnitude

(2) One's complement

(3) Two's complement

(4) Excess - 1023.

For unsinged numbers, the largest number represented by 11 bits is: $2^{11}-1=2017$

(1) Sign and magnitude.

The first bit is reserved for sign. Therefore, the smallest numer is
$-(2^{10}-1)=-1023$
the largest numer is
$2^{10}-1=1023$

(2) One's completement
In this method, the positive numbers are listed as
000 0000 0000 -> 0
011 1 1 1 1 1 1 1 1 -> $2^{10}-1$

The negative numbers range from
1 1 1 1 1 1 1 1 1 1 1 (which is 0)
to
100 0000 0000 (which is -1023)

The range is :
-1023 to 1023

(3) Two's complement
In this method, the positive numbers are listed as
000 0000 0000 -> 0
011 1 1 1 1 1 1 1 1 -> $2^{10}-1$ = 1023

The negative numbers range from
1 1 1 1 1 1 1 1 1 1 1 (which is 1)
to
100 0000 0000 (which is -1024)

The range is :
-1024 to 1023

(4) Excess-1023

The range for the unsigned 11 bits is 0 – 2048. This range is biased by -1023 in the excess-1023 method. Therefore, the range is:
-1023 - 1025

Q8. (5 points) If we use 8 bits for signed integers, show how we would solve the problem of subtracting 70_{10} from 30_{10} using 2's complement.

In two's complement:

30_{10} = 0001 111 0

-70_{10} = 1011 1010

Subtracting 70 from 30 with the two's complement method means "adding 0001 1110 and 1011 1011"

The sum is

  0001 1110
+ 1011 1010

= 1101 1000

Converting to decimal, this numer is -40.

Q9. (5 points) How many zeroes are in the binary representation of the decimal number resulting from the sum of $2^{13}+2^{7}+1$?

$$(2^{13}+2^{7}+1)_{10}=(10\,0000\,1000\,0001)_{2}$$

There are 11 zeros in this binary number.

Q10. (5 points) Suppose Matlab uses 64 bits to represent real numbers and 16 bits for characters, what is the size of A, B, C, D (in terms of bytes, respectively) if the following commands are executed?

A(2:6) = 2:6

B = 'cds130'

C = int16(B)

D = 1:3:301

Answer:

A(2:6) = 2:6 creates a vector [0, 2, 3, 4, 5, 6]. For each element 64 bis (or 8 bytes) are needed.

The size of this vector is $6\,x\,8\,bytes = 48\,bytes$

B = 'cds130' creates a vector ['c', 'd', 's', '1', '3', '0']. Each character needs 2 bytes.

The size of this vector is $6\,x\,2\,bytes = 12\,bytes$

C = int16(B). This comand converststs 'cds130' to an int16 type (2 bytes each) vector with six elements.
The size of this vector is $6\,x\,2\,bytes = 12\,bytes$

D=1:3:301 Creates a vector of 101 elements. Therefore, the size of this vector is:
$101 * 8\,bytes = 808\,bytes$

Q11. (5 points) Use a single command to create a matrix (assign it to a variable named B) such that

B = [1, ¼, 1/9, 1/16, 1/25, 1/36]

DO NOT type the vector explicitly.

The corresponding one-line matlab command is:

B = (1:6).^(-2)

Q12. (10 points) What is the output after executing the following MATLAB code:

```
clear all;
first_variable  = 4;
second_variable = 3;
third_variable = 12;
vector_created1 ( first_variable) = second_variable
```

upto this point, vector_created1 =
[0, 0, 0, 3]

```
vector_created2 (second_variable) = first_variable
```

upto this point, vector_created2 =
[0, 0, 4]

```
vector_created3 = [vector_created1, vector_created2] + third_variable
```

now, vector_created3 has the conent

[12, 12, 12, 15, 12, 12, 16]

Q13. (10 points) What is the output after executing the following MATLAB code:

```
clear;

mat1  = [2:5]*2
mat2 = [2:-1: -1].^2
mat3 = mat2 ./ mat1;
mat3
```

mat1 =
[4, 6, 8, 10]
mat2 =
[2, 1, 0, 1]
mat3 =
[½, 1/6, 0, 1/10]

Q14. (10 points) An anonymous function defined in matlab is a function that is not stored in a program file, but associated with a variable.

$f(x,y)=\sin^2(x^2)+\cos^2(y^2)+e^{x-y}$

Calculate the values of $f(f(0.3,0.4), f(0.2,0.1))$ using the defined anonymous function in Matlab.

Define the anonymous function:

```
>>    f = @(x,y) sin(x^2))^2 + (cos(y^2))^2 + exp(x -y)
```

Using this function:

```
>> f(f(0.3, 0.4), f(0.2, 0.1))
```

= 1.0438

Q15. (15 points) Write a script called 'exam.m' that asks the user to

(1) provide three numbers and name them as variables x, y, and z;
(2) write a user-defined function my_power(x,y,z) to evaluate the value of $x^y - x^z$
(3) use the user-provided values to test the results of this function and show the results.

Present your matlab code.

step 1: Create a user-defined math function my_power.m and save this file.

```
function f=my_power(x, y, z)
f = x^y-x^z
end
```

step 2: The script for users to input three values and test the math function, exam.m

```
x = input('The first variable is: ');
y = input('The second variable is: ');
z  = input('The third variable is: ');

value = my_power(x,y,z);

disp('The result of running the math function is:');
disp(value);
```

step 3: Test the code

input three values 3, 4, 5

```
 The first variable is: 3
 The second variable is: 4
 The third variable is:    5
  f =
       -162

 The result of running the math function is:

ans:
      -162
```